Temperature dependence of AlN reflectance spectra

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Aluminum nitride (AlN), one of the III-V compound semiconductors with a wurtzite crystalline structure, is promising not only for the use of passivation of semiconductor surfaces and insulators for high temperatures, but also for the use of optical devices at ultraviolet spectral region and surface acoustic wave devices, because it has wide band gap and high sound velocity. Recently, it has received more attention from the properties of its alloys with GaN and InN which permit the fabrication of AlGaInN based shortest-wavelength semiconductor laser diode. In spite of the prospects of AlN in device applications, experimental data on the optical properties are surprisingly scarce, although several theoretical studies were performed. We have reported reflectance spectra measured with synchrotron radiation on AlN single crystals in the energy from 6 to 120 eV at room temperature [1,2]. In this work, we investigated the temperature effect on the reflectance spectra of AlN single crystal.

AlN films were grown epitaxially on (0001) α-Al_2O_3 substrates using the chemical reaction of trimethylaluminum with ammonia [3]. Reflection high-energy electron diffraction results showed all the AlN samples to be a single crystal and to have an orientation relationship of (0001)AlN//(0001) α-Al_2O_3. The samples were placed in a continuous-flow cryostat with a coolant (liquid helium) from a storage vessel to a vacuum-insulated sample space. The sample temperature could be maintained at any temperature with an accuracy of 0.1 K in the range of 23 to 300 K by controlling the flow of the coolant and the power supplied to the electrical heater. Reflectance spectra were measured from 6 to 10 eV at BL7A of the UVSOR in the Institute for Molecular Science as a function of temperature. Figure 1 shows the reflectance spectra of AlN at various temperatures. With decreasing temperature, the energy positions of the dominant structures in the reflectance spectra shift towards higher energies. The shifts of these dominant structures can be well described by the Bose-Einstein expression, and the calculated parameters by fitting the experimental data to the expression have a good agreement with those obtained by absorption spectra measurements [4].

References

[1] Q.X. Guo, M. Nishio, H. Ogawa, and A. Yoshida, Phys. Rev. B 55, R15987 (1997).

[2] Q.X. Guo, M. Nishio, H. Ogawa, and A. Yoshida, J. Crystal Growth 189/190, 457 (1998).

[3] M. Morita, N. Uesugi, S. Isogai, K. Tsubouchi, and N. Mikoshiba, Jpn. J. Appl. Phys. 20, 17 (1981).

[4]Q.X. Guo and A. Yoshida, Jpn. J. Appl. Phys. 33, 2453 (1994).

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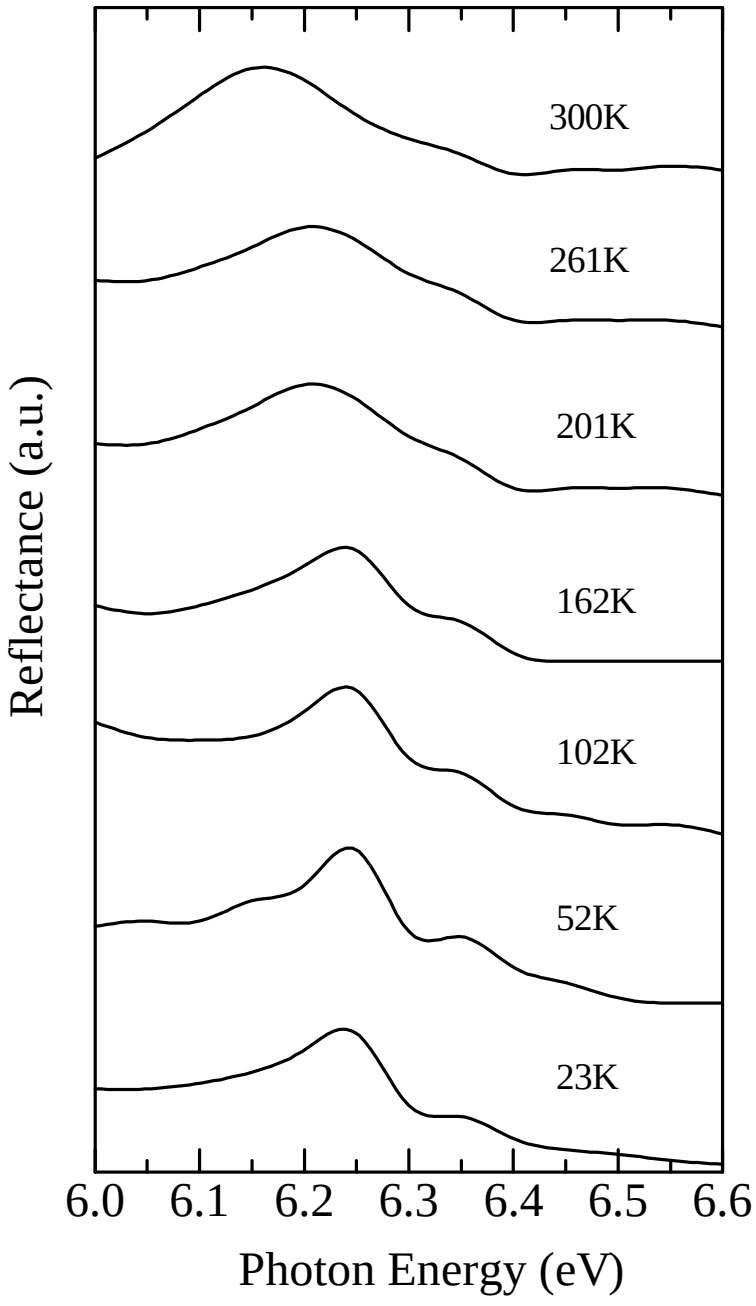

Figure 1. Reflectance spectra of AlN at various temperatures.